

## **REMARKS**

In view of the above amendments and the following remarks, reconsideration of the objection and rejection and further examination are hereby requested.

The specification and abstract have been reviewed and revised to improve their English grammar and U.S. form. The amendments to the specification and abstract have been incorporated into a substitute specification and abstract. Attached are two versions of the substitute specification and abstract, a marked-up version showing the revisions, as well as a clean version. No new matter has been added.

Claims 1-3 have been canceled without prejudice or disclaimer to the subject matter contained therein and are replaced by new claims 4-18.

The Abstract of the Disclosure was objected to because it contained more than 150 words. It is submitted that this objection is inapplicable to the presently amended Abstract because the word count is now less than 150 words.

The Disclosure was objected to because pages 10-12 of the specification recited claim numbers. It is submitted that this objection is inapplicable to the presently amended specification because the claim numbers have been removed from the specification.

Claims 1-3 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. This objection is considered moot based on the cancellation of original claims 1-3 and is submitted to be inapplicable to the present claims because new claims 4-18 have been drafted so as to particularly point out and distinctly claim the subject matter which the Applicant regards as the invention.

Claims 1-3 were rejected under 35 U.S.C. § 102(b) as being anticipated by Schobl (US 4,394,872). This rejection is submitted to be inapplicable to the present claims for the following reasons.

#### **New Claims 4-8 are Patentable over Schobl**

New independent claim 4 recites a thruster valve for controlling the flow of a high temperature fluid, the thruster valve comprising in part, (1) a valve casing having a fluid flow passage in which a valve plug is disposed, and a through hole; (2) a graphite liner arranged in said through hole, and having a cavity and drive rod through holes; (3) a drive rod slidably received in said drive rod through holes such that a seal is formed and maintained between the drive rod and the graphite liner, wherein the drive rod is arranged so as to be driven in an axial direction by an actuator; and (4) at least one relief hole formed so as to extend through said graphite liner and said valve casing in a direction transverse to the axial direction of the drive rod so as to communicate the cavity of the graphite liner with the exterior of the valve casing, such that any high temperature fluid leaked from the fluid flow passage into the cavity is provided a drain passage from the cavity to the exterior of the valve casing.

In summary, new independent claim 4 recites a thruster valve for controlling the flow of a high temperature fluid wherein a relief hole is arranged such that any high temperature fluid which leaks between the drive rod and the graphite liner and into the cavity is drained to the exterior of the valve casing rather than continuing to leak to the exterior end of the drive rod.

In contrast, Schobl teaches a valve assembly for packing removal wherein a valve apparatus of the valve assembly includes a self-contained means for the removal of valve packing (col. 2, lines 558 to col. 3, lines 1-7). Specifically, Schobl teaches a packing means 110 (i.e., a liner) made of graphite-impregnated fiber (col. 5, line 58), wherein the packing means 110 is separated into upper and lower portions within the inner cylindrical chamber 82, and wherein the lantern ring 112 is secured between the two portions of the packing means 110 so that a space is formed therebetween (col. 5, lines 58-66). Moreover, the lantern ring 112 has a plurality of radial conduits 114 connected to a lubrication part 116. This arrangement of radial conduits 114 within the lantern ring 112 is for lubricating the packing means 110. More specifically, the lubrication part 116 extends from the radial conduits 114 such that lubrication can be fed from outside the valve assembly for the purpose of lubricating the inside of the valve assembly. Further, the valve assembly of Schobl includes a drive fluid hole 130 which allows pressurized fluid to flow from the

outside of the valve assembly to the inside of the valve assembly for the purpose of pushing out the packing means 110. The lubrication part 116 is closed by the lubrication plug 118, and the drive fluid hole 130 is closed by plug 132 during operation of the valve assembly.

Based on the above discussion, it is apparent that Schobl teaches a valve assembly for packing removal which utilizes both a lubrication part 116 for lubricating the internal components of the valve assembly, and a drive fluid hole 130 for allowing pressurized fluid to push out the packing means. On the other hand, new claim 4 recites a relief hole of a thruster valve, wherein the relief hole extends in a direction transverse to the axial direction of the drive rod and is positioned so as to drain to the exterior of the valve casing any high temperature fluid, which leaks down the shaft and into the cavity. Further, Schobl teaches a valve assembly wherein the lubrication part and the drive fluid hole are closed by a plug during operation of the valve assembly, but does not teach that a relief hole that is open during operation of the thruster valve so as to allow leaked fluid to drain out of the thruster valve. As a result, the arrangement of and claimed features of the relief hole are not disclosed or suggested by Schobl.

In light of the features recited in new claim 4 that are lacking from Schobl, it is apparent that new independent claim 4 is not anticipated by Schobl.

Furthermore, it is submitted that a person having ordinary skill in the art at the time of the invention would not have been motivated to modify Schobl or to make any combination of the references of record in such a manner as to result in, or otherwise render obvious, the present invention as recited in new independent claim 4. Accordingly, it is respectfully submitted that new independent claim 4 and the claims that depend therefrom are clearly patentable over the prior art of record.

#### **New Claims 9-18 are Patentable over Schobl**

New independent claims 9 and 14 recite a thruster valve including the same: (1) graphite liner; and (2) at least one relief hole, as recited in new independent claim 4.

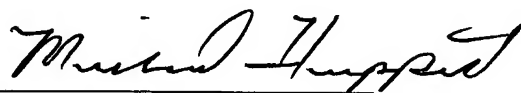
For the same reasons discussed above, it is submitted that the Schobl reference does not anticipate or render obvious the invention as recited in new independent claims 9 and 14.

Accordingly, it is respectfully submitted that new independent claims 9 and 14 and the claims that depend therefrom are clearly patentable over the Schobl.

In view of the above amendments and remarks, it is submitted that the present application is now clearly in condition for allowance, and an early notice thereof is earnestly solicited. The Examiner is invited to contact the undersigned by telephone to resolve any remaining issues.

Respectfully submitted,

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~~TITLE OF THE INVENTION~~

**HIGH TEMPERATURE RESISTANT SEAL STRUCTURE,  
VALVE COMPRISING THE SAME  
AND AEROSPACE CRAFT SIDE THRUSTER**

BACKGROUND OF THE INVENTION

~~TECHNICAL FIELD~~ 1. FIELD OF THE INVENTION

5 The present invention relates to a high temperature resistant seal structure of an axial directional slide shaft of a valve, etc., handling a high temperature fluid in a side thruster of an aerospace craft, etc. The present invention also relates to a valve comprising this seal structure as well as relates to a side thruster of an aerospace craft comprising this valve.

15 ~~BACKGROUND ART~~ 2. DESCRIPTION OF THE RELATED ART

Fig. 2 is a longitudinal cross sectional view of a prior art side thruster valve used in an aerospace craft, etc. and description will be made based thereon.

20 As shown in Fig. 2, a thruster valve 01 comprises a valve casing 02. The valve casing 02 comprises a supply port 03 through which working medium a is supplied and a nozzle 04 from which the working medium a is discharged. Within the valve casing 02, the supply port 03 and a nozzle throat portion 05 of the nozzle 04 communicate with each other.

25 Also, within the valve casing 02, a valve plug 06 opening

and closing the nozzle throat portion 05 is arranged being connected to one end of a drive rod 07. The drive rod 07 slidably passes through a drive rod through hole 09 of the valve casing 02 and the other end of the drive rod 07 projecting outside of the valve casing 02 is connected to an actuator 08 of a linear actuator, rotary actuator or the like so that the drive rod 07 is driven along the axial direction thereof as shown by a bidirectional arrow X. The actuator 08 is fixed to a fixing member (not shown).

The working medium a supplied through the supply port 03 flows through a space formed between the nozzle throat portion 05 and the valve plug 06 ~~to be~~ and is jetted from the nozzle 04 so that a thrust of the side thruster is generated. At this time, the actuator 08 drives the valve plug 06 so as to open and close the nozzle throat portion 05 and to change ~~a~~ the area of the flow path area thereof the working medium a. Thereby, the thrust can be changed continuously or step-wise.

In the drive rod through hole 09 of the valve casing 02, an elastomer seal 010 is provided so as to form a seal structure preventing the working medium a from leaking through between the valve casing 02 and the drive rod 07. It is to be noted that the term “elastometer” means a high molecular substance having a rubber elasticity.

Conventionally, in the slidable portion between the valve casing 02 and the drive rod 07 of the thruster valve 01 as mentioned above, such a metal seal as usually used for sealing between

stationary faces cannot be used, as the sealing is not sufficiently achieved because of the sliding motion of the sealing face. Hence, the elastomer seal 010 of an O-ring or the like is used.

For this reason, if a high temperature fluid, such as  
5 combustion gas, is used as the working medium a, the elastomer seal 010 often melts because of the heat transmitted from the drive rod 07 so that the combustion gas leaks to form a leak gas b. Thus, the actuator 08 is exposed to the high temperature environment by the leak gas b and there is caused a risk of operation disorder of the  
10 actuator 08.

Also, if a structure to protect the elastomer seal 010 and the actuator 08 is to be employed, the valve casing 02 has to be made larger by that extent and there is a problem that this leads to a larger size and mass increase of the side thruster device.

15 Also, as the side thruster device uses the valve casing 02 made of a metal, the slide resistance between the valve casing 02 and the drive rod 07 becomes large under the high temperature in the drive rod through hole 09. Thus, the drive force of the thruster valve 01 is inevitably made larger and there is caused a problem that  
20 this again leads to a larger size of the actuator 08.

#### DISCLOSURE BRIEF SUMMARY OF THE INVENTION

Hence, in order to solve the problems in the high  
25 temperature resistant seal structure used in the prior art side

thruster for an aerospace craft or the like, it is an object of the present invention to provide a high temperature resistant seal structure that ~~has not~~does not have the problem of exposing the actuator to the high temperature environment, ~~to leading~~to an operation disorder. and Moreover, another object of the present invention is to provide a valve that can reduce the valve drive force as well as ~~to provide~~ a side thruster comprising this valve for use in an aerospace craft or the like.

In order to achieve the above-mentioned object, the present invention provides ~~the means as follows:~~the following:

(1) ~~As a first means, in~~In the first aspect of the present invention, wherein a high temperature resistant seal structure, provided in a casing into which a high temperature fluid is supplied, ~~comprising~~the present invention includes a shaft through hole portion into which a shaft to be driven in an axial direction of the shaft is inserted passing through the shaft ~~through~~-hole portion, a liner, made of graphite, comprising a cavity formed therein and slidable holes provided at both end portions of the cavity ~~is~~are provided being inserted into the shaft through hole portion so that the shaft slidably passes through the slidable holes with a seal state being maintained between the shaft and the liner. Further, the present invention includes ~~and a relief hole is provided being which~~is bored in a lateral direction relative to the axial direction of the shaft so that the cavity and the outside of the casing communicate with each other.

According to the first ~~means~~aspect of the present invention constructed as mentioned above, even if the high temperature fluid leaks into the cavity through a minute gap between the shaft and the graphite-made liner, ~~it~~ the high temperature fluid is discharged outside of the casing through the relief hole. Thereby, the high temperature fluid is prevented from leaking in the axial direction of the shaft and ~~a~~ any slide resistance between the shaft and the graphite-made liner can also be reduced.

(2) ~~As a second means, provided is~~ A second aspect of the present invention includes a valve comprising the high temperature resistant seal structure of the first ~~means~~aspect, wherein the shaft is a drive rod of a valve plug of the valve, and an actuator, operable to drive ~~driving~~ the drive rod in the axial direction of the shaft, is connected to an end of the shaft (i.e. drive rod) which projects, ~~projecting outside of the valve, of the drive rod.~~

According to the second ~~means~~aspect of the present invention constructed as mentioned above, in the valve comprising the high temperature resistant seal structure of the first ~~means~~aspect, the actuator is prevented from being exposed to the high temperature environment. Thereby, in addition to the function and effect of the first ~~means~~aspect, the casing of the valve and the actuator can be made smaller.

(3) ~~As a third means, provided is~~ A third aspect of the invention includes an aerospace craft side thruster comprising the valve of the second ~~means~~aspect.

According to the third ~~means~~aspect of the present invention constructed as mentioned above, in the aerospace craft side thruster comprising the valve of the second ~~means~~aspect, even if ~~the a~~ high temperature fluid of combustion gas, etc. is used as a working medium, the actuator of the thruster valve is prevented from being exposed to the high temperature environment caused by ~~the a~~ leaking of the working medium. Thereby, an aerospace craft having a high reliability and reduced mass can be obtained.

10 ~~BRIEF~~ \_\_\_\_\_ DETAILED DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal cross sectional view of a valve of an aerospace craft side thruster of an embodiment according to the present invention.

Fig. 2 is a longitudinal cross sectional view of a valve of a prior art aerospace craft side thruster.

~~BEST MODE FOR CARRYING OUT~~ \_\_\_\_\_ DETAILED  
DESCRIPTION OF THE INVENTION

With reference to Fig. 1, a side thruster device for an aerospace craft or the like of one embodiment according to the present invention will be described. Fig. 1 is a longitudinal cross sectional view of a side thruster valve of the side thruster for an aerospace craft or the like of the present embodiment.

As shown in Fig. 1, a thruster valve 1 comprises a valve casing 2. The valve casing 2 comprises a supply port 3 through

which working medium a of combustion gas or the like as a high temperature fluid is supplied and a nozzle 4 from which the working medium a is discharged. Within the valve casing 2, the supply port 3 and a nozzle throat portion 5 of the nozzle 4 communicate with each other.

Also, within the valve casing 2, a valve plug 6 for opening and closing the nozzle throat portion 5 is arranged being connected to one end of a drive rod 7. The drive rod 7 passes through a drive rod through hole 9 of the valve casing 2 and the other end of the drive rod 7 projecting outside of the valve casing 2 is connected to an actuator 8 of a linear actuator, rotary actuator or the like so that the drive rod 7 is driven along the axial direction thereof as shown by a bidirectional arrow X. The actuator 8 is fixed to a fixing member (not shown).

The working medium a supplied through the supply port 3 flows through a space formed between the nozzle throat portion 5 and the valve plug 6 ~~to be~~ and is jetted from the nozzle 4 so that a thrust of the side thruster is generated. At this time, the actuator 8 drives the valve plug 6 so as to open and close the nozzle throat portion 5 and to change ~~a~~ the area of the flow path area thereof of the working medium a. Thereby, the thrust can be changed continuously or step-wise.

A graphite liner 20 is ~~provided being~~ inserted into the drive rod ~~through~~ hole 9 of the valve casing 2. The graphite liner 20 comprises a cavity 20a formed therein so that a space is formed

between the drive rod 7 and the graphite liner 20. The graphite liner 20 comprises slidable holes 20b, and 20c, wherein slidable holes 20b and 20c are provided~~arranged~~ at both end portions of the cavity 20a so that the drive rod 7 slidably passes through both of the  
5 slidable holes 20b, 20c with a seal state being maintained between the drive rod 7 and the graphite liner 20.

A relief hole 21 is bored ~~elongating to extend~~ from the cavity 20a in the direction substantially orthogonal to the axial direction of the drive rod 7 and passing through both ~~of~~ the graphite liner 20 and  
10 the valve casing 2. Thus, when the drive rod 7 is assembled passing through the graphite liner 20, the cavity 20a formed around the drive rod 7 communicates with the outside of the thruster valve 1.

In the thruster valve 1 of an aerospace craft side thruster of the present embodiment as described above, the working medium a  
15 supplied through the supply port 3 is jetted from the nozzle 4 corresponding to the opening of the nozzle throat portion 5 set by the valve plug 6. At this time, a portion of the working medium a leaks as a leak gas b to flow into the cavity 20a through a minute gap between the drive rod 7 and the graphite liner 20 at the slidable hole  
20 20b on the inner side of the thruster valve 1.

The leak gas b entering the cavity 20a is discharged outside of the thruster valve 1 through the relief hole 21 so that the leak gas b is substantially prevented from leaking in the axial direction of the drive rod 7 through the slidable hole 20c on the outer side of the  
25 thruster valve 1 or on the actuator 8 side.

Thereby, the actuator 8 can be prevented from being exposed to the leak gas b of the high temperature working medium a of the combustion gas or the like and the problem to cause the operation disorder can be solved. ~~Also~~Referring to the prior art, the valve casing that has so far been made in a large size for protecting the elastomer seal 010 (Fig. 2) and the actuator 08 (Fig. 2) from the leak gas b can be made smaller in size and lighter in weight.

Moreover, as the graphite has a very high heat resistant temperature and a small friction resistance even ~~in the at~~ high temperature, ~~it can stand for~~ the graphite can withstand the high temperature of the working medium a and the leak gas b. Also, the slide resistance between the drive rod 7 and the graphite liner 20 can be reduced. Thereby, the actuator 8 also can be made smaller in size.

The seal structure of the thruster valve 1 as described above can be generally effectively applied as a high temperature resistant seal structure of an axial directional slide shaft of a valve, etc. handling a high temperature fluid. By so applying the present seal structure, a leakage of the high temperature fluid along the slide shaft can be prevented and an operation disorder of the surrounding parts and components in the high temperature environment caused thereby can be prevented and an axial directional drive force of the slide shaft can be reduced by the reduced slide resistance. Thus, an effect that the actuator, etc. can be made smaller and lighter is obtained.

If the axial directional slide shaft is a drive rod of a valve plug, by the valve having the above-mentioned high temperature resistant seal structure, an effect to prevent the problem that the actuator is exposed to the high temperature environment to lead to an operation disorder can be obtained, in addition to the above-mentioned effect of making the valve casing and the actuator smaller, etc. Thereby, a reliability of the valve can be enhanced.

Also, in an aerospace craft side thruster using the thruster valve having the above-mentioned high temperature resistant seal structure, the leakage of the high temperature fluid of combustion gas, etc. as the working medium is prevented, Accordingly, the operation disorder of the actuator due to the high temperature environment is prevented and the thruster valve and the actuator can be made smaller so that the entire side thruster device can be made smaller. Thereby, an aerospace craft side thruster having a high reliability and reduced mass can be obtained.

In the above, while the embodiment according to the present invention has been described, the present invention is not limited thereto but various modifications thereof can be added to the concrete structure within the scope of the invention as ~~appended~~ recited in the claims.

For example, while the illustration of the relief hole 21 has been shown such that there are provided three relief holes 21 bored in one side portion of the drive rod 7, the number of the relief holes 21 may be one or a plurality. Also, the relief holes 21 may be bored

in an arbitrary side portion (including an entire periphery) of the drive rod 7 according to the discharge condition of the leak gas b and the arrangement of the surrounding parts and components.

Also, while the relief hole 21 has been illustrated to  
5 ~~elongate-extend~~ linearly in the direction orthogonal to the drive rod 7, if the elongating direction in which the relief hole extends is lateral as a whole relative to the axial direction of the drive rod 7, the relief hole 21 may be inclined or bent ~~on the way of the elongation~~. Moreover, the relief hole 21 may be connected with a gas discharge  
10 pipe (not shown) ~~on the way of the elongation~~.

#### INDUSTRIAL APPLICABILITY

~~(1) According to the invention of Claim 1, a high-temperature resistant seal structure, provided in a casing into which  
15 a high temperature fluid is supplied, comprising a shaft through hole portion into which a shaft to be driven in an axial direction of the shaft is inserted passing through the shaft through hole portion is constructed such that a liner, made of graphite, comprising a cavity formed therein and slidable holes provided at both end portions of  
20 the cavity is provided being inserted into the shaft through hole portion so that the shaft slidably passes through the slidable holes with a seal state being maintained between the shaft and the liner and a relief hole is provided being bored in a lateral direction relative to the axial direction of the shaft so that the cavity and the outside  
25 of the casing communicate with each other. Thus, even if the high-~~

temperature fluid leaks into the cavity through a minute gap between the shaft and the graphite made liner, it is discharged outside of the casing through the relief hole. Thereby, the high temperature fluid is prevented from leaking in the axial direction of the shaft. Also, the problem that the surrounding parts and components connected to the shaft end are exposed to the high temperature fluid to lead to an operation disorder can be prevented. Thus, the valve casing that has so far been made in a large size for protecting the parts and components from the high temperature environment can be made smaller in size and lighter in weight. Further, the slide resistance between the shaft and the graphite made liner can be reduced and the shaft drive force can be also reduced.

(2) According to the invention of Claim 2, a valve comprising the high temperature resistant seal structure of Claim 1 is provided being constructed such that the shaft is a drive rod of a valve plug of the valve and an actuator driving the drive rod in the axial direction of the shaft is connected to an end, projecting outside of the valve, of the drive rod. By the valve comprising the high temperature resistant seal structure of the invention of Claim 1, the actuator is prevented from being exposed to the high temperature environment. Thus, by the function and effect of the invention of Claim 1, the casing of the valve and the actuator can be made smaller and a reliability of the valve can be enhanced.

(3) According to the invention of Claim 3, an aerospace craft side thruster is provided comprising the valve of the invention of

~~Claim 2. By the aerospace craft side thruster comprising the valve  
of the invention of Claim 2, even if the high temperature fluid of  
combustion gas, etc. is used as a working medium, the actuator of  
the thruster valve is prevented from being exposed to the high  
5 temperature environment caused by the leaking of the working  
medium to lead to an operation disorder. Thus, by the function and  
effect of the invention of Claim 2, the thruster valve and the actuator  
can be made smaller, the side thruster device can be made smaller  
and an aerospace craft having a high reliability and reduced mass  
10 can be obtained.~~

## ABSTRACT

~~A high temperature resistant seal structure having no problem that an actuator is exposed to a high temperature environment to lead to an operation disorder, a valve having a reduced valve drive force and an aerospace craft side thruster are provided. In a high temperature resistant seal structure, provided in a casing into which a high temperature fluid is supplied, comprising a shaft through hole portion into which a shaft to be driven in an axial direction of the shaft is inserted passing through the shaft through hole portion, a liner, made of graphite, comprising a cavity formed therein and slidable holes provided at both end portions of the cavity is provided being inserted into the shaft through hole portion so that the shaft slidably passes through the slidable holes with a seal state being maintained between the shaft and the liner and a relief hole is provided being bored in a lateral direction relative to the axial direction of the shaft so that the cavity and the outside of the casing communicate with each other.~~A thruster valve for controlling a flow of high temperature fluid, comprising a valve casing, a graphite liner, a drive rod, and at least one relief hole. The graphite liner is disposed in a through hole within the valve casing. The drive rod being slidably received in drive rod through holes within the graphite liner, such that a seal is formed and maintained between the drive rod and the graphite liner. The drive rod is arranged so as to be driven in an axial direction by

an actuator attached to an end of the drive rod arranged outside the valve casing. At least one of the relief holes is formed to extend through the graphite liner and valve casing to communicate the cavity with the exterior of the valve casing provide a drain passage.

- 5 ~~By this construction, Thus, leakage of the high temperature fluid in the shaft axial direction is prevented, the surrounding parts and components connected to a shaft end portion are prevented from being exposed to the high temperature fluid and a shaft drive force is reduced. Also, the valve and aerospace craft side thruster~~
- 10 ~~comprising the present seal structure can be made smaller and lighter and reliability thereof can be enhanced.~~